THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to Geographic Information Systems (GIS)

Prepared by
Bryan L. Perdue

CADD/GIS Technology Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to GIS

**Nam et ipsa scientia potestas est.**
**(Knowledge is power.)**

**Sir Francis Bacon**

*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to GIS

GIS is:

Powerful information…

easily accessed…

for effective installation management



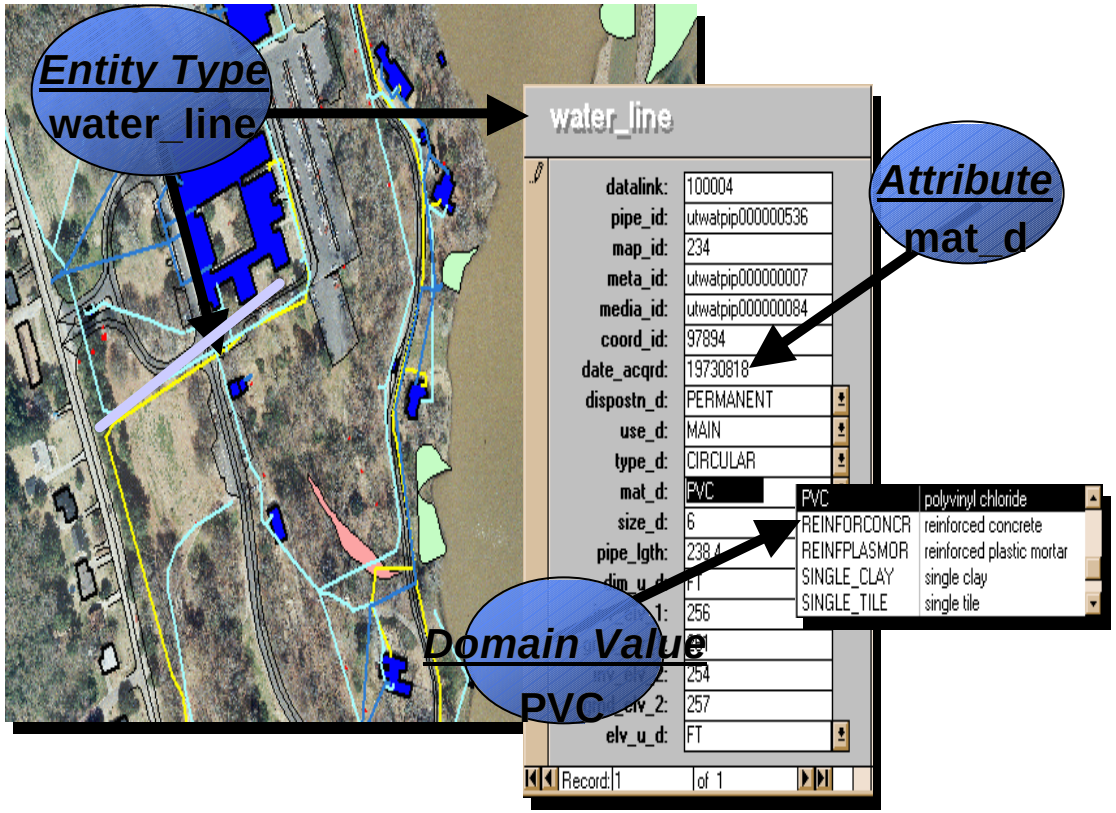
*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to GIS

It's

A method of storing, accessing and viewing information about your installation or project





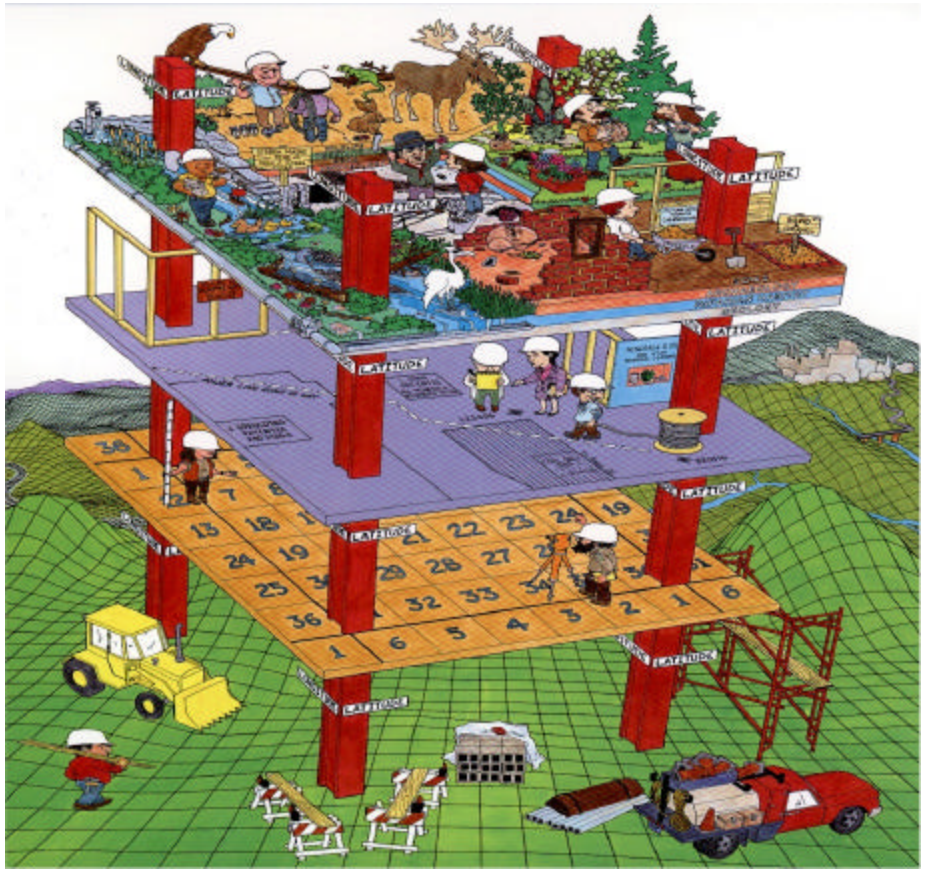

smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to GIS

That allows you to:

Reference information spatially



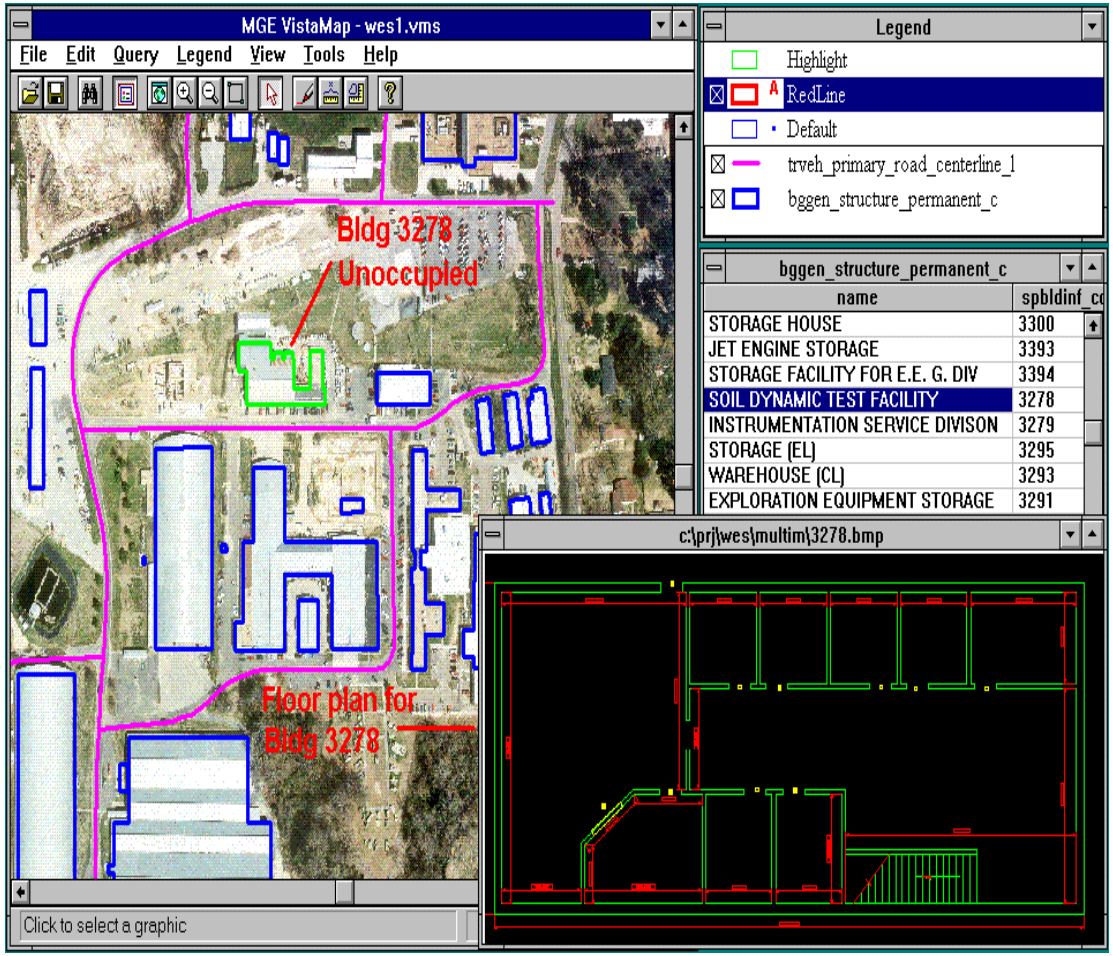


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to GIS

View information graphically




*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

Share information with others



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to GIS

To make sense of the swirl of information…

that is today's defense environment

*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# What is GIS?

Definition of GIS:

***An integrated computer system capable of capturing, storing, retrieving, analyzing, and displaying geospatial information that provides the user with knowledge of locational information about your installation, project, or objective.***



smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# What is GIS?

***GIS is a decision-making tool that produces useful information in a cost effective manner***



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Key Element of GIS

The ability of a GIS to analyze spatial data is frequently seen as a key element in its definition, and has often been used as a characteristic which distinguishes the GIS from systems whose primary objective is map production.'



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Map Graphic

- Maps are symbolic abstractions--"generalizations" or "representations"--of reality




smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Spatial Analysis

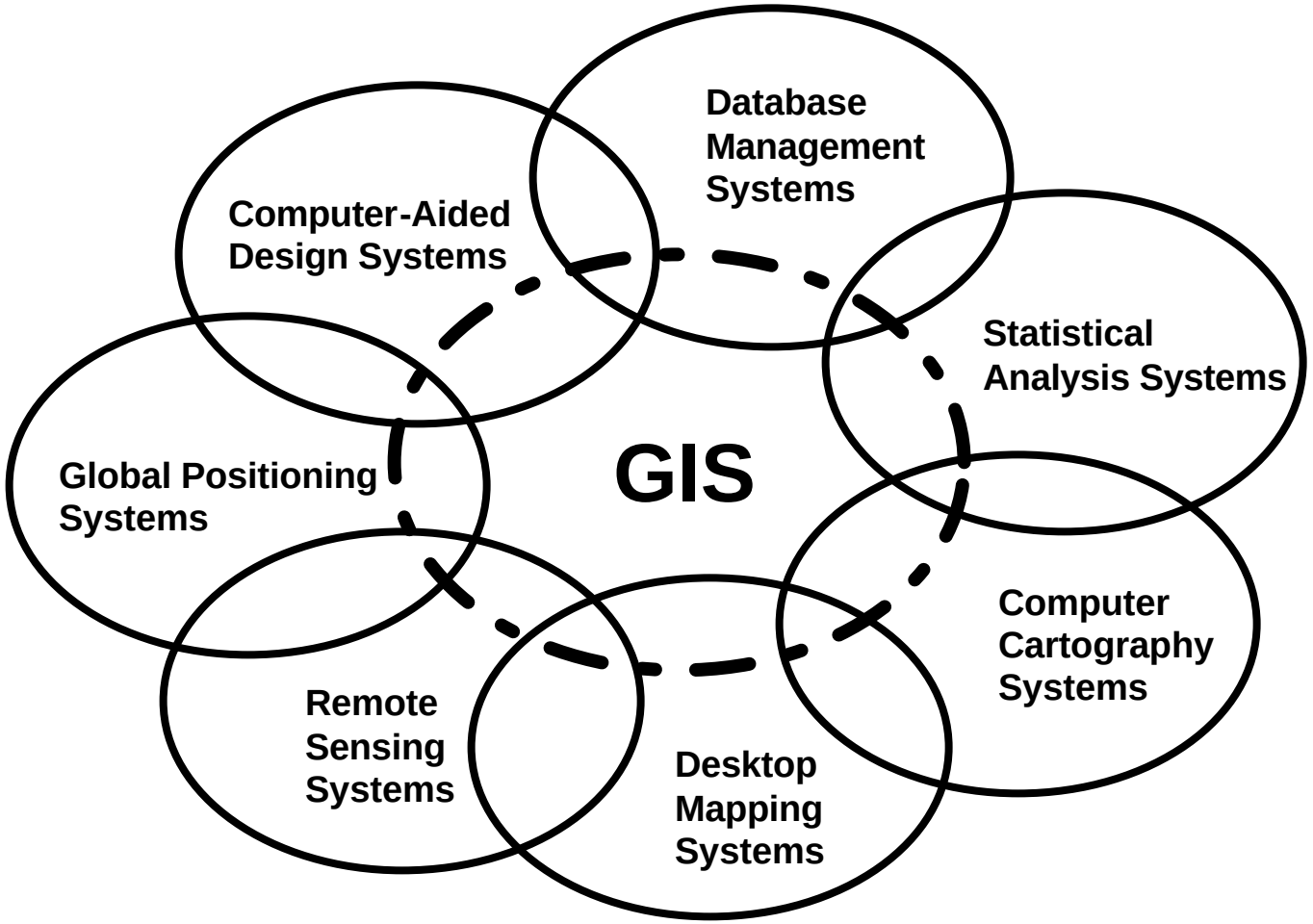
Spatial analysis is that set of analytical methods which requires access to both the attributes of the object under study and to their locational information.



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Related Technologies

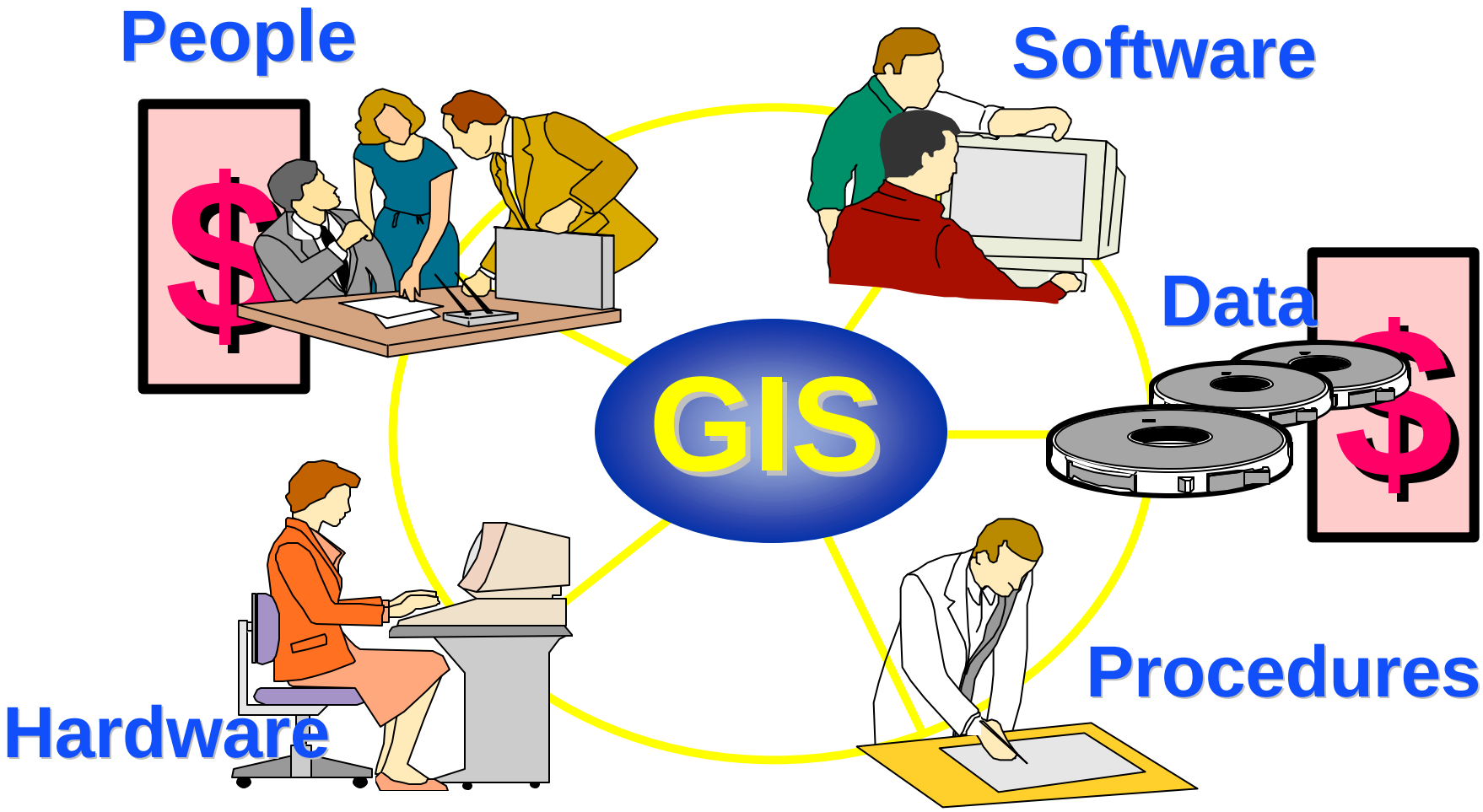





*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Geographic Information System

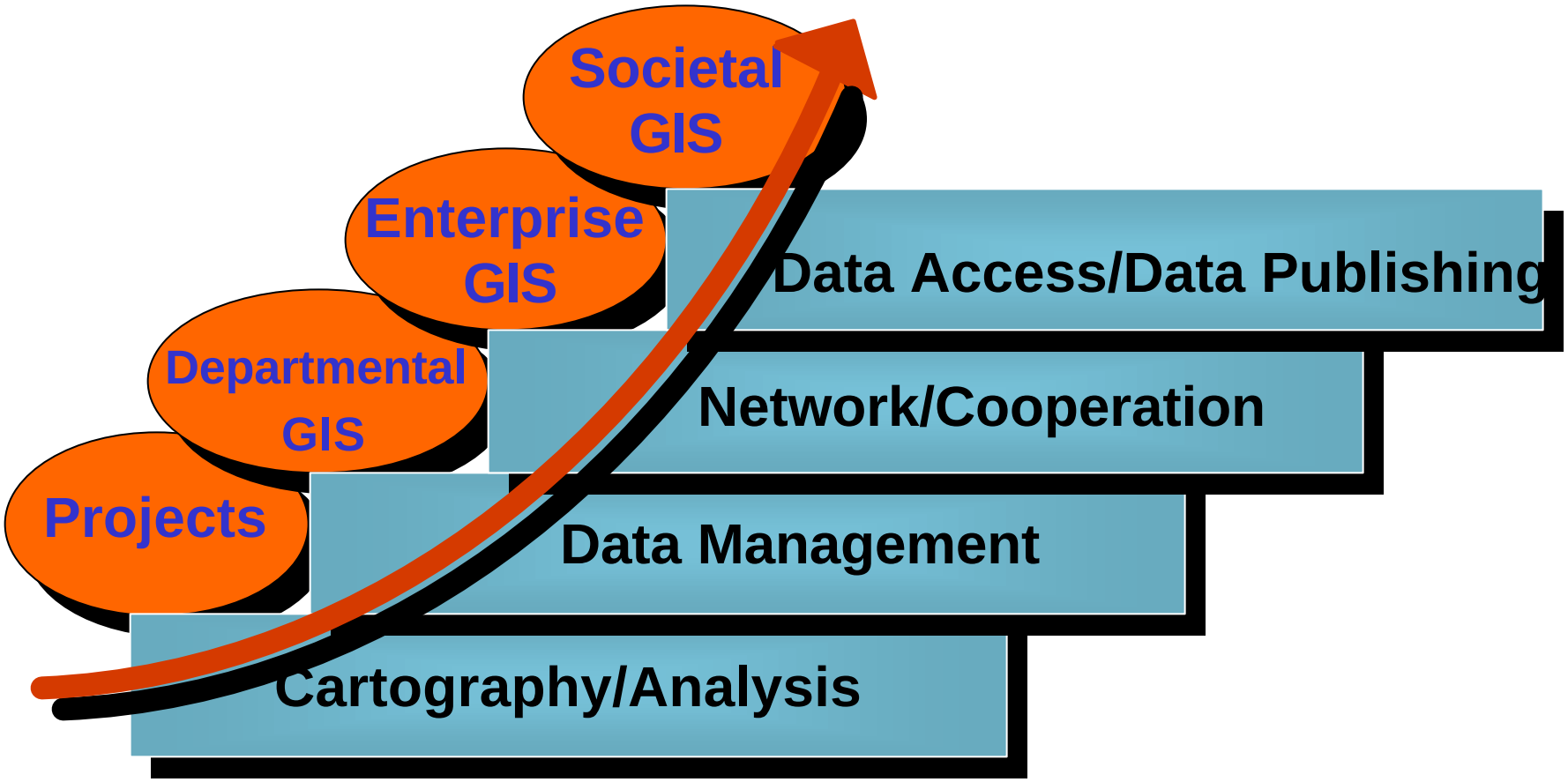





smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Evolution






*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# CADD/GIS

## Fundamentally different technologies

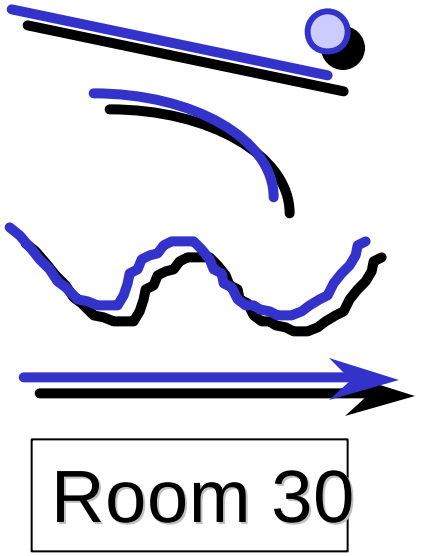
- CADD - technology for symbolically representing features
- GIS - database oriented, analytical methodology for working geographically


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# CADD Data Elements

- Lines
- Circles and arcs
- Line strings (polylines)
- Symbols (cells/blocks)
- Text
- etc.

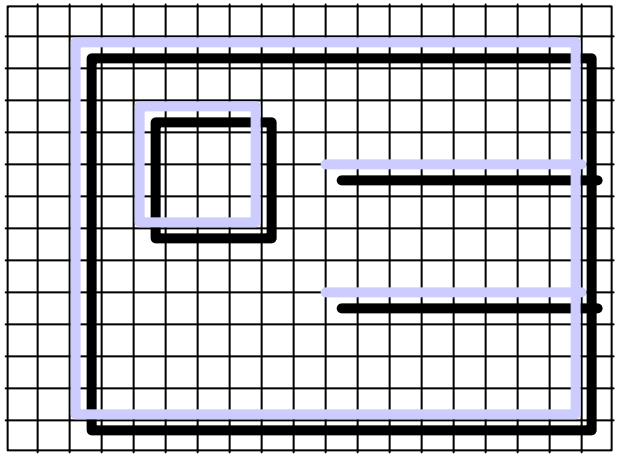




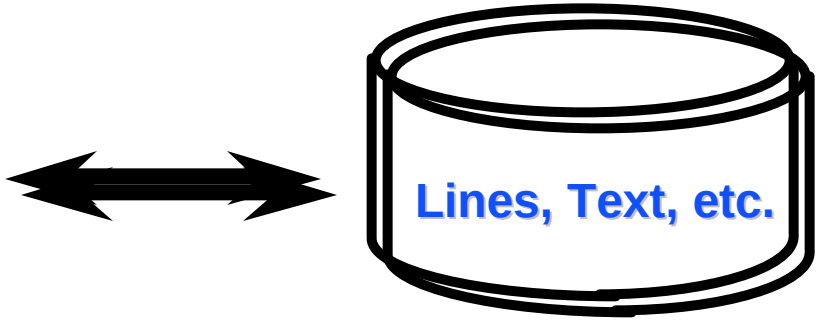

*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# CADD Data Structure



0,0




Graphic Data Files

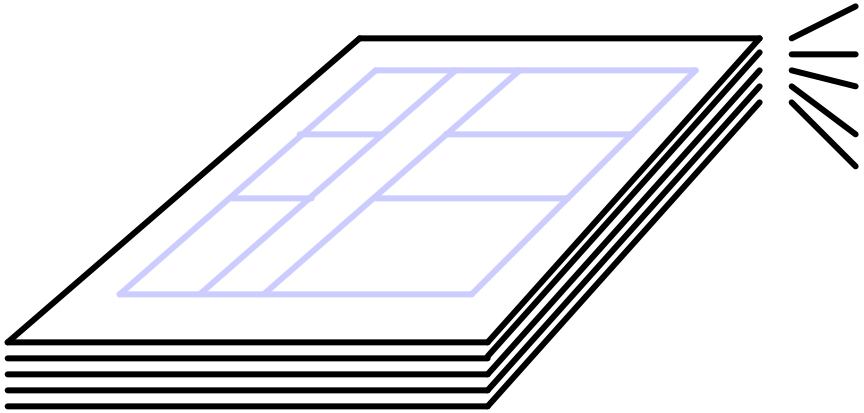
**Data referenced to a *Cartesian XYZ two* or *three* dimensional coordinate system**



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# CADD Data Structure



**Floorplan Layer**
**Dimensions Layer**
**Symbols Layer**
**Border Layer**
**etc.**

**Data arranged by *layers/levels* and by drawing file.**

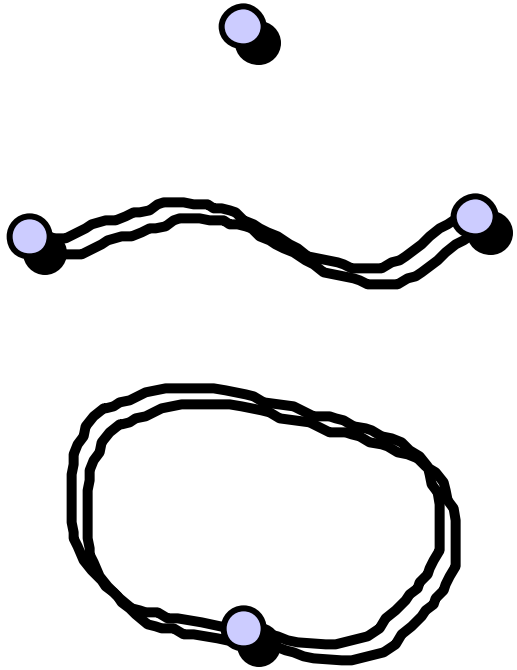


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Data Elements

- Nodes / Points
- Lines / Arcs
- Areas / Polygons

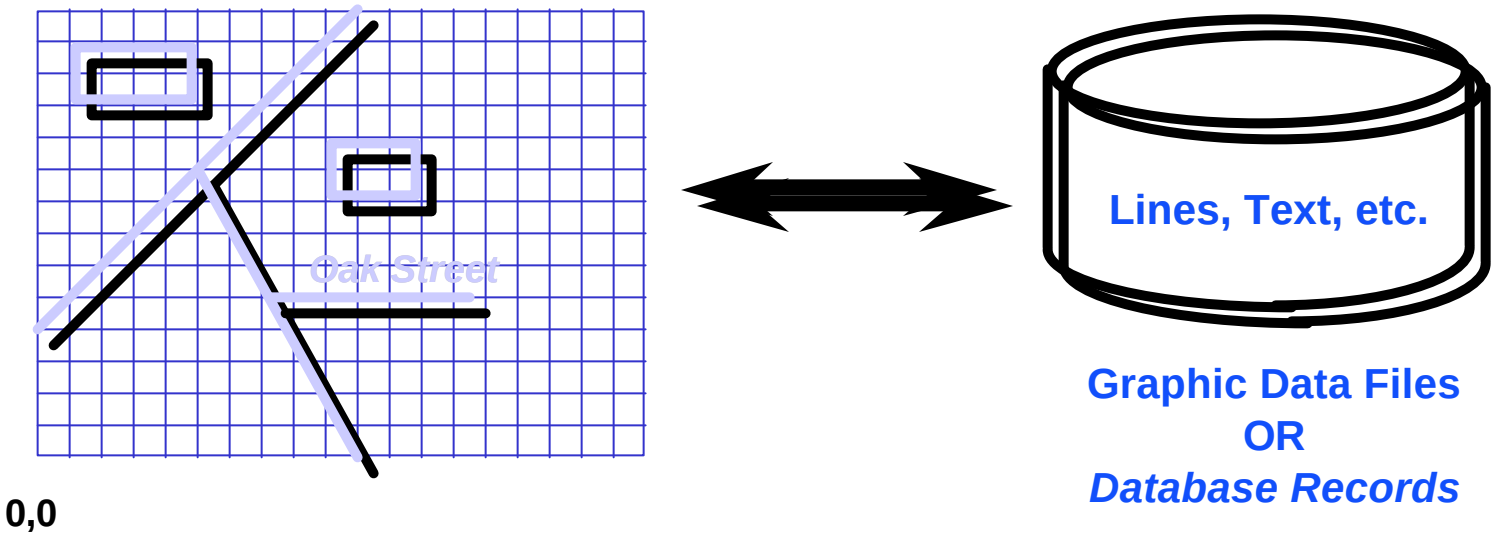




*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Data Structure



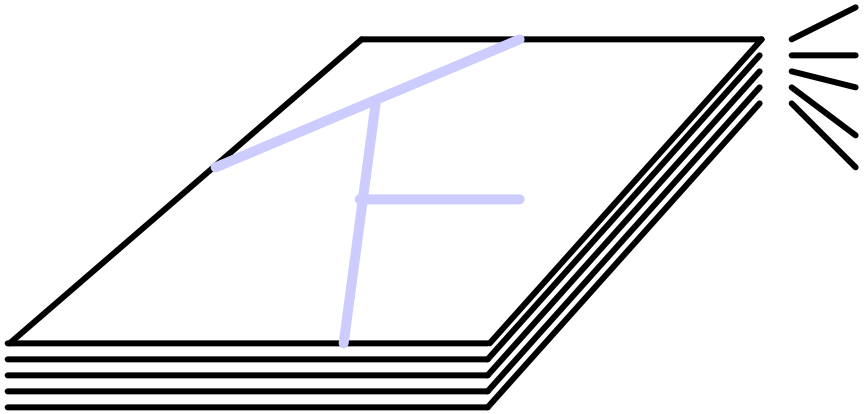

**Data referenced to a *Projected XYZ two or three* dimensional coordinate system**



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Data Structure



**Roads File**
**Structures File**
**Water System File**
**Boundaries File**
**etc.**

**Data arranged by *themes* (map sheet file),**
**or by *features* (coverage file)**



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# CADD / GIS Differences

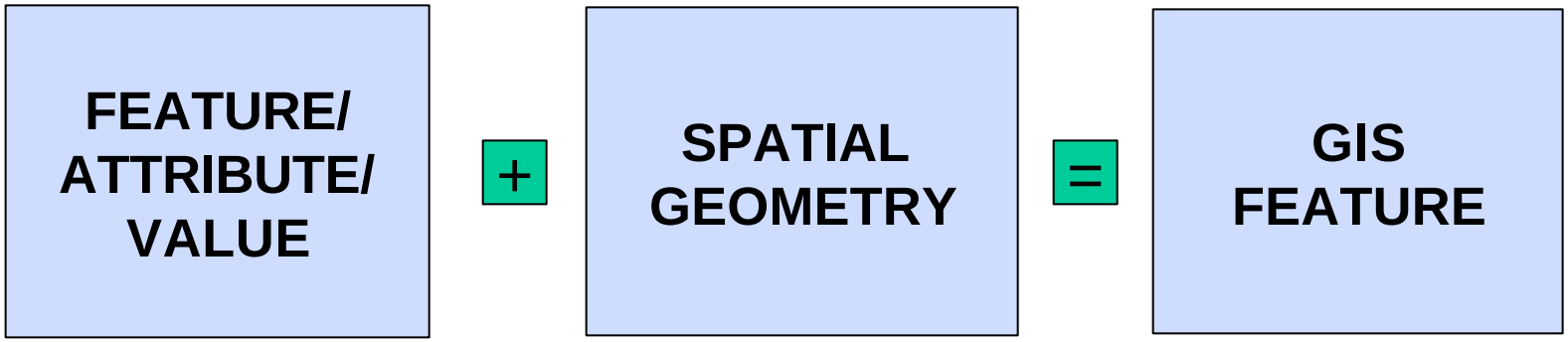
- Data model
  - CADD: list of graphic elements described by mathematical parameters or set of parameters
  - GIS: relationships between features in geographic space
- Functions
  - CADD: design, display, and query
  - GIS: adds database, cartography and spatial analysis


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Data

## The GIS Data should be a collection of Geographic Features




**The spatial geometry specification is left to be handled by the GIS and CADD software vendors.**



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Feature/Attribute/Value

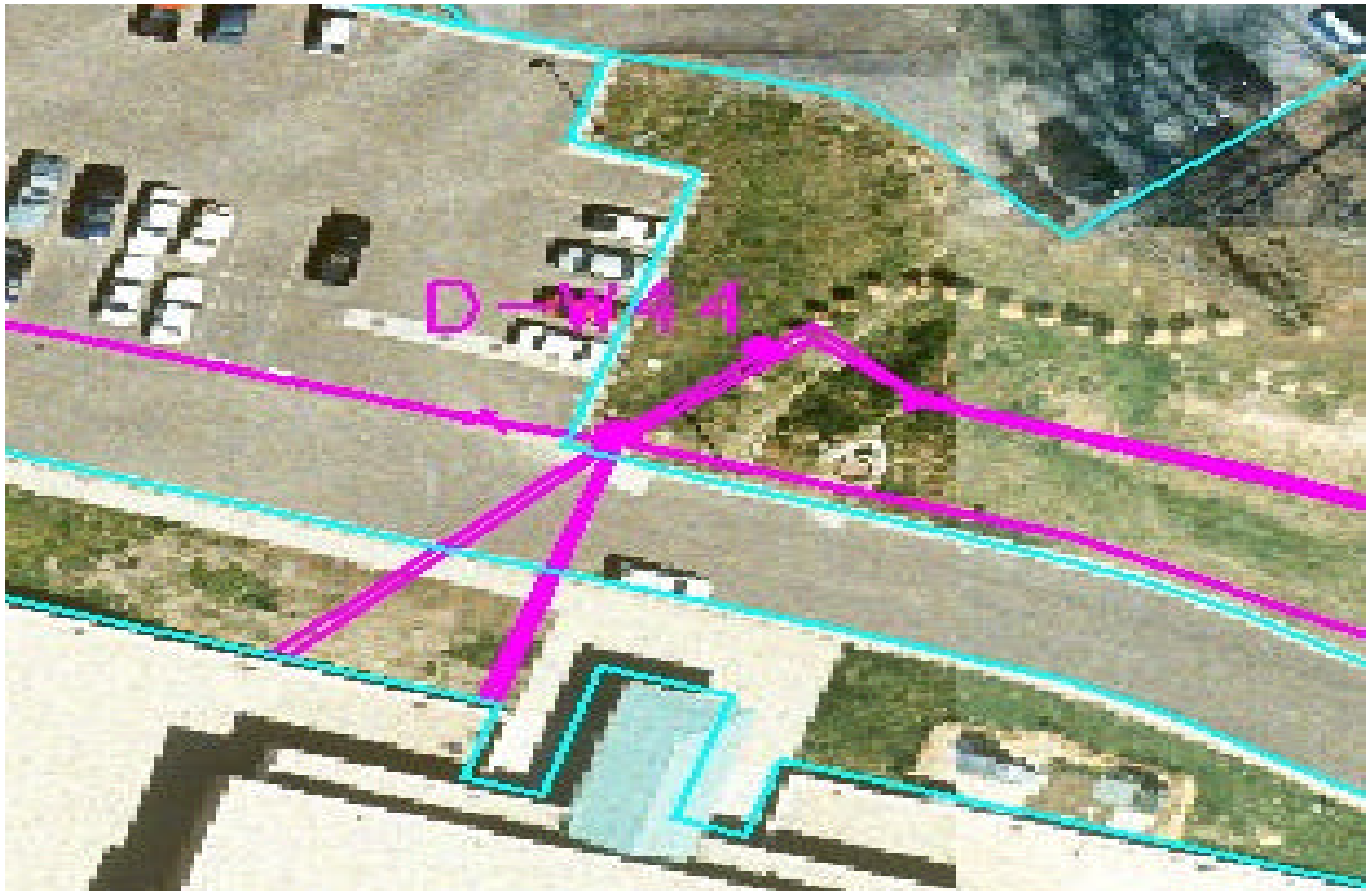
Microsoft Access - [cdrelpar : Table]

File Edit View Insert Format Records Tools Window Help

| mslink | parcel_id | mapid | address_id | owner_id | section_no | proj_name | tract_no | parea_size | twnshp |
|---|---|---|---|---|---|---|---|---|---|
| 1000633 | 1000633 | 100039 | 9 | 9 | 29 | Chain of Rocks | b-178 | 5.651223 | 4N |
| 1000594 | 1000594 | 100039 | 9 | 9 | 29 | Chain of Rocks | b-131 | 7.569156 | 4N |
| 1000530 | 1000530 | 100039 | 8 | 8 | 6 | Chain of Rocks | a-24 | 4.313801 | 4N |
| 1000757 | 1000757 | 100039 | 7 | 7 | 14 | Chain of Rocks | a-7 | 10.06117 | 3N |
| 1001021 | 1001021 | 100039 | 6 | 6 | 30 | Chain of Rocks | b-175 | 0.721636 | 4N |
| 1000507 | 1000507 | 100039 | 5 | 5 | 22 | Chain of Rocks | a-2 | 1.453892 | 3N |
| 1000505 | 1000505 | 100039 | 5 | 5 | 22 | Chain of Rocks | a-3 | 37.02981 | 3N |
| 1000506 | 1000506 | 100039 | 45 | 125 | 22 | Chain of Rocks | a-4 | 3.11477 | 3N |
| 1000533 | 1000533 | 100039 | 44 | 197 | 31 | Chain of Rocks | a-38 | 46.99532 | 4N |
| 1000578 | 1000578 | 100039 | 43 | 63 | 31 | Chain of Rocks | b-112 | 0.572798 | 4N |
| 1001013 | 1001013 | 100039 | 43 | 55 |  | Chain of Rocks | a-84 | 0.513786 | 3N |
| 1000592 | 1000592 | 100039 | 43 | 56 | 29 | Chain of Rocks | b-126 | 6.314286 | 4N |
| 1001028 | 1001028 | 100039 | 43 | 56 | 29 | Chain of Rocks | b-177 | 42.95975 | 4N |
| 1000626 | 1000626 | 100039 | 43 | 57 | 31 | Chain of Rocks | b-170 | 19.99236 | 4N |
| 1000586 | 1000586 | 100039 | 43 | 54 | 31 | Chain of Rocks | b-120 | 0.701553 | 4N |
| 1000577 | 1000577 | 100039 | 43 | 62 | 31 | Chain of Rocks | b-111 | 1.713401 | 4N |
| 1000572 | 1000572 | 100039 | 43 | 61 | 31 | Chain of Rocks | b-106 | 1.154667 | 4N |
| 1000560 | 1000560 | 100039 | 43 | 59 | 12 | Chain of Rocks | a-70 | 4.717465 | 3N |
| 1000584 | 1000584 | 100039 | 43 | 53 | 31 | Chain of Rocks | b-118 | 1.485571 | 4N |
| 1000568 | 1000568 | 100039 | 43 | 53 | 31 | Chain of Rocks | b-102 | 0.410378 | 4N |
| 1001025 | 1001025 | 100039 | 43 | 52 | 31 | Chain of Rocks | b-113 | 0.393718 | 4N |
| 1000604 | 1000604 | 100039 | 43 | 64 | 31 | Chain of Rocks | b-137 | 0.513597 | 4N |
| 1001016 | 1001016 | 100039 | 43 | 50 | 31 | Chain of Rocks | b-168 | 0.216684 | 4N |
| 1000602 | 1000602 | 100039 | 43 | 166 | 20 | Chain of Rocks | b-135 | 138.1288 | 4N |
| 1000516 | 1000516 | 100039 | 43 | 49 | 11 | Chain of Rocks | a-10 | 52.56823 | 3N |
| 1000556 | 1000556 | 100039 | 43 | 49 | 12 | Chain of Rocks | a-64-1 | 16.46245 | 3N |
| 1000545 | 1000545 | 100039 | 43 | 48 | 12 | Chain of Rocks | a-56 | 4.751908 | 3N |
| 1000544 | 1000544 | 100039 | 43 | 47 | 12 | Chain of Rocks | a-55 | 3.505314 | 3N |
| 1000524 | 1000524 | 100039 | 43 | 51 | 1 | Chain of Rocks | a-19 | 49.63012 | 3N |
| 1000555 | 1000555 | 100039 | 43 | 173 | 12 | Chain of Rocks | a-62 | 11.21107 | 3N |
| 1000538 | 1000538 | 100039 | 43 | 190 | 2 | Chain of Rocks | a-47 | 1.720721 | 3N |
| 1001014 | 1001014 | 100039 | 43 | 110 | 31 | Chain of Rocks | b-166 | 0.488053 | 4N |

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Spatial Geometry



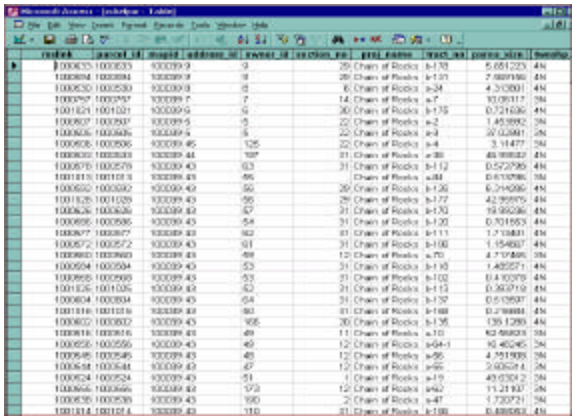
*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Geospatial Data Set

## The Data Set should be a collection of Geospatial Features

**FEATURE/ ATTRIBUTE/ VALUE**

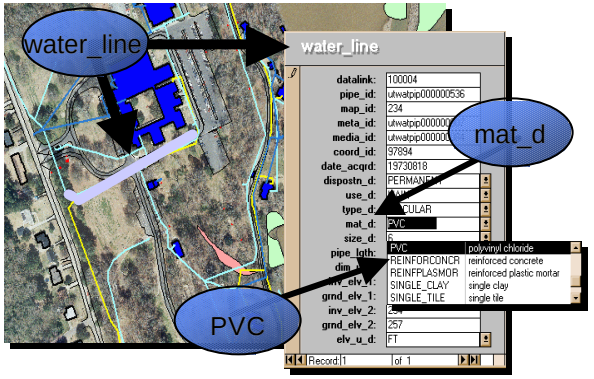


+

**SPATIAL GEOMETRY**

=

**GEOSPATIAL FEATURE**




*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Capabilities

- Location — What is at…?
- Condition — Where is it…?
- Trend — What has changed…?
- Routing — Which is the best way…?
- Pattern — What is the pattern…?
- Modeling — What if…?


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Capabilities

- Location What is at…?
- Involves querying a database to determine the types of features that occur at a given place
- Ex. What is the material composition of a specified water line?


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Applications

- Condition  Where is it…?
- Involves finding the location of sites which have certain characteristics (find the intersection of data sets)
- Ex. Where are unexploded ordnance sites within 200 miles of a road?


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Applications

- Trend  What has changed…?
- Involves monitoring how things change over time
- Ex. What is the change in the change in land use within 100 yards of the installation's fence line?


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Applications

- Pattern What is the pattern…?
- Allows scientists and planners to describe and compare the distribution of phenomena and understand the processes which account for their distribution
- Ex. Is there some pattern in the distribution of diseases which are thought to be caused by mosquitoes?


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Applications

- Modeling  What if…?
- Allows different models of the world to be evaluated
- Ex. Which areas of the post will be affected by a 200 year flood event?


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Data Collection Methods

- Clearinghouses
- Imagery
- Digitizing
- Global Positioning Systems


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Emerging Technology

1/31/01

*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Object Technology

**Object Technology is: the set of otherwise diverse programming languages, techniques, tools, environments and methodologies that derive their value from the use of objects.**

| | |
|---|---|
| **O-O Programming Languages** | **Software Developers (e.g., C++, Java)** |
| **O-O & O-R Databases** | **Database Developers (e.g., Oracle 8i, O[2])** |
| **Object Methodologies -** describing/modeling domain "things" & their characteristics using a formal notation | **Data Modelers and Domain Experts** (e.g., CASE Tools for UML, Express[]) |
| **Object Components - object classes, software components** | **Users** (e.g. ESRI ArcInfo 8, Laserscan Gothic, Smallworld, Graphisoft ArchiCAD, Autodesk Architectural Desktop 2.0) |



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Object Characteristics

State (What it knows) -

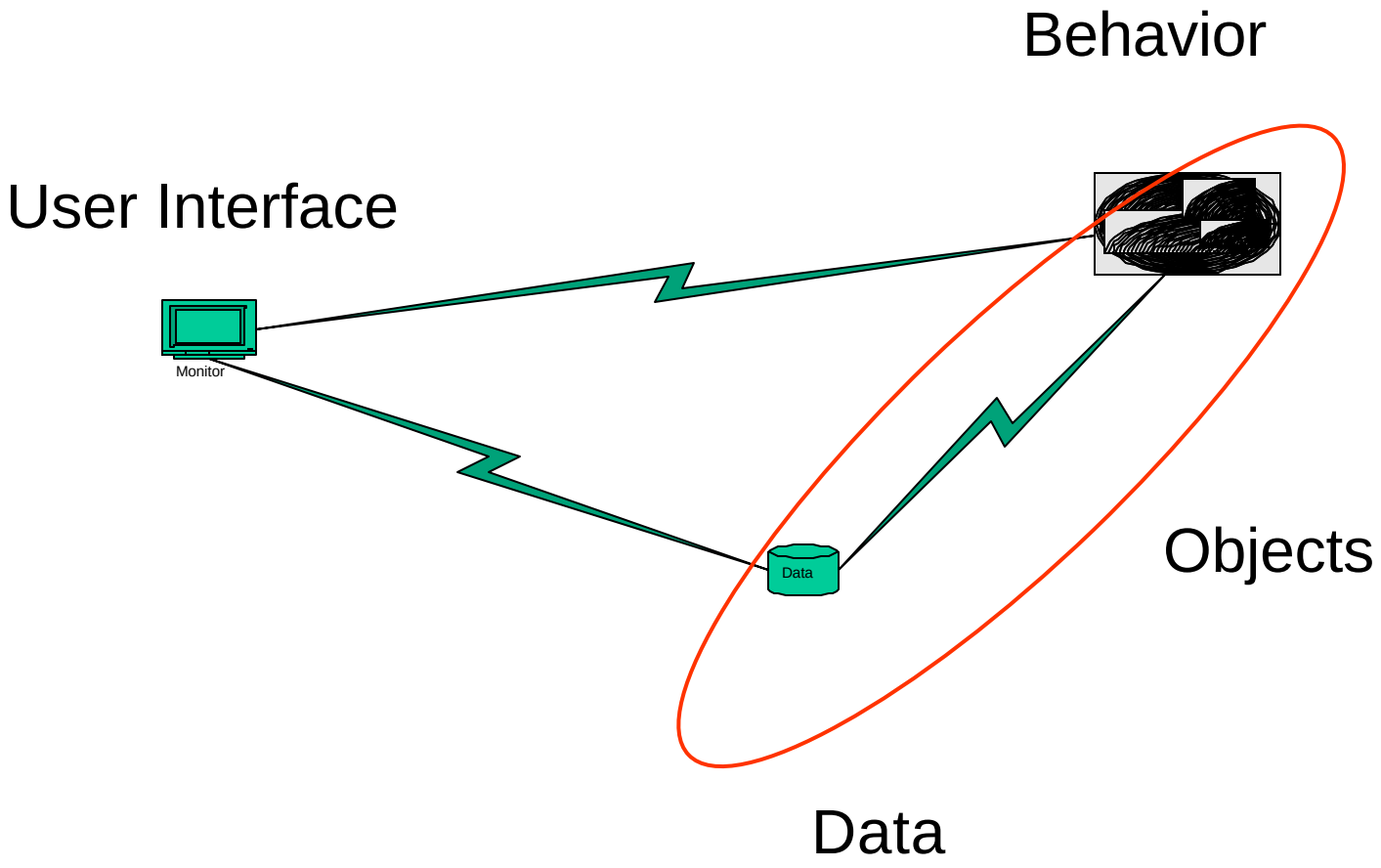
- state is hidden from user I.e., Encapsulation
- ability to maintain state differentiates objects from set of functions (piece of software code.)
- example: door - locked/unlocked; waterline - functioning/broken

- Behavior (What it can do)
  - set of things you can ask it to do
  - user/client of object can ask it to perform some behavior(s)
  - example: door - swings open/closed; waterline - transports water
- Identity (Which object is it)
  - reference & address a specific object
  - example: door - ID#221; waterline - key#55342


smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Components of Software






*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# GIS Objects

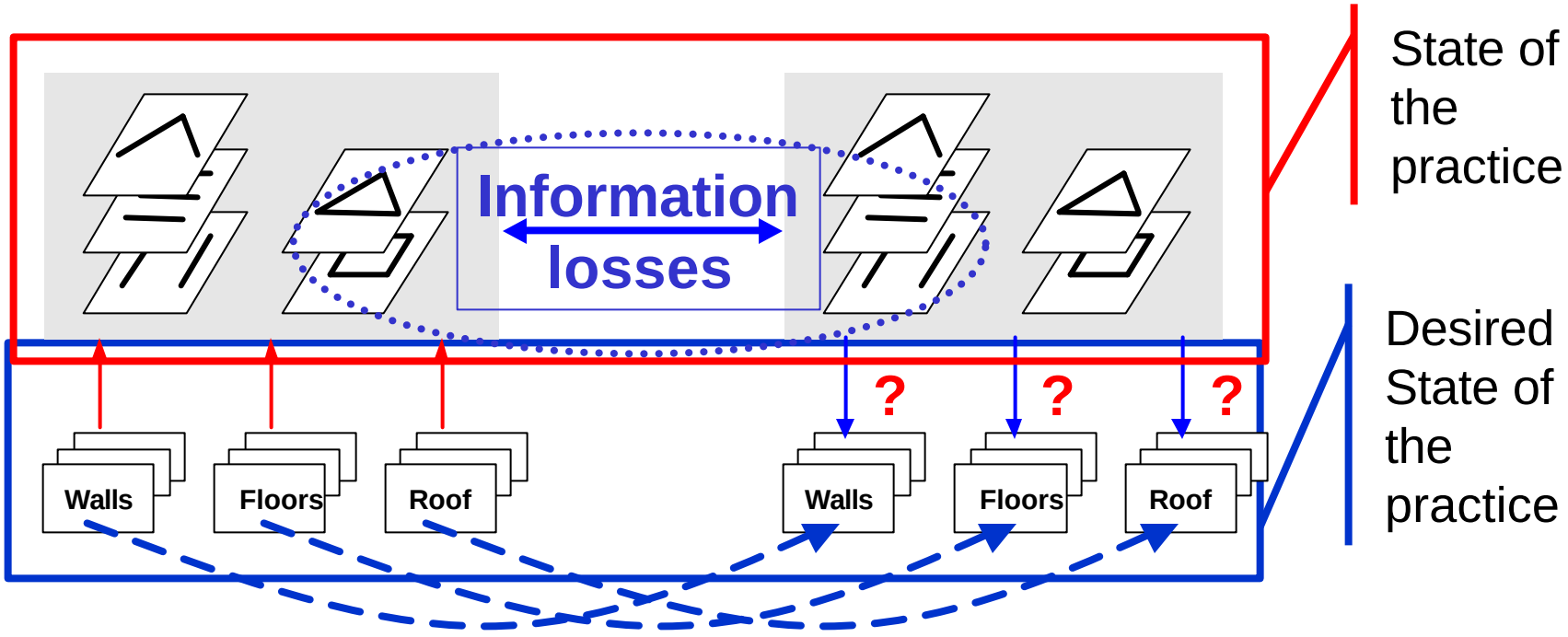
- GIS application of object technology primarily used today by Utility Co. and other network applications to model facilities ***(e.g. gas, water, electric, communications, road networks.)***
- Also see some OO-base GIS use by large national charting agencies for data support feature data capture, update, & maintenance.
- Considerable Object-Based GIS experimentation going on NIMA, TEC, USGS, and elsewhere.
- Benefits of OO-based GIS:
  - easier to capture unique data types & systems/facilities.
  - ability to model real world phenomena as an object with various graphic representations and accompanying attributes ***(e.g. various scale topo maps/hydro charts.)***
  - ability to add behaviors to ensure data integrity.


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Objects Share Intelligence

- When we exchange only graphics data, we lose knowledge e.g. Architect/Designer/Engineer, …
- With Objects you begin to include some of this knowledge into the data.



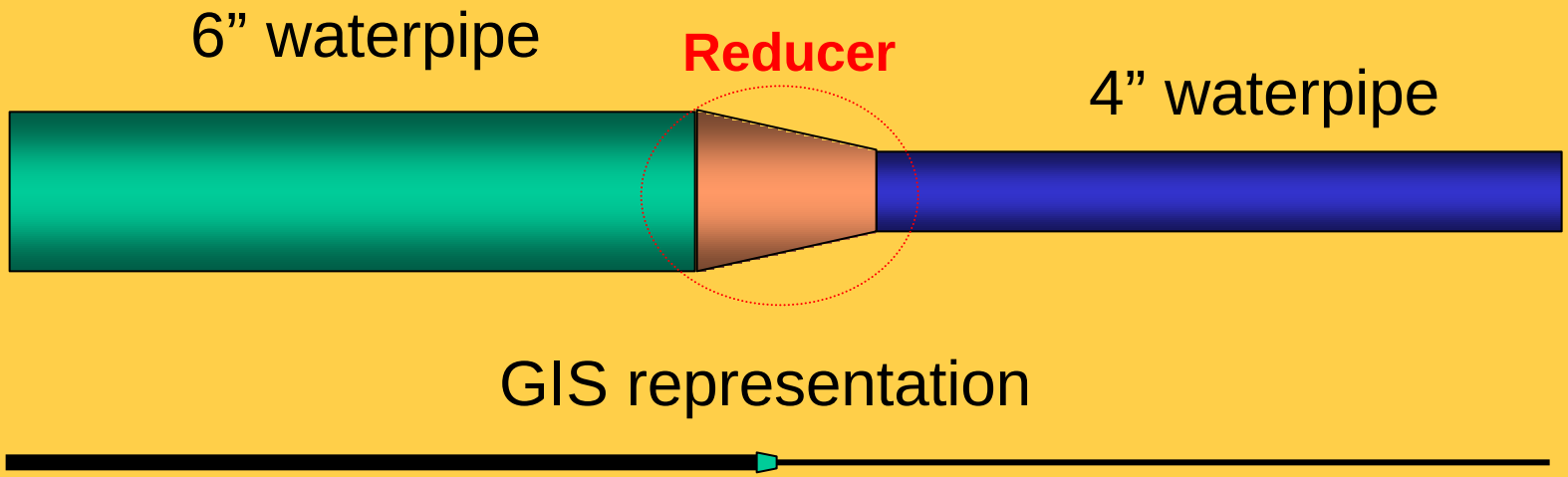



smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Example Intelligent GIS Object

Waterpipe --includes behavior(s) that specifies what it can connects with (e.g., 6” main can connect to another 6” main or needs a reducer to connect to 4” waterpipe.)





smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Evolving

- The technology has evolved from paper maps and wooden models to …..

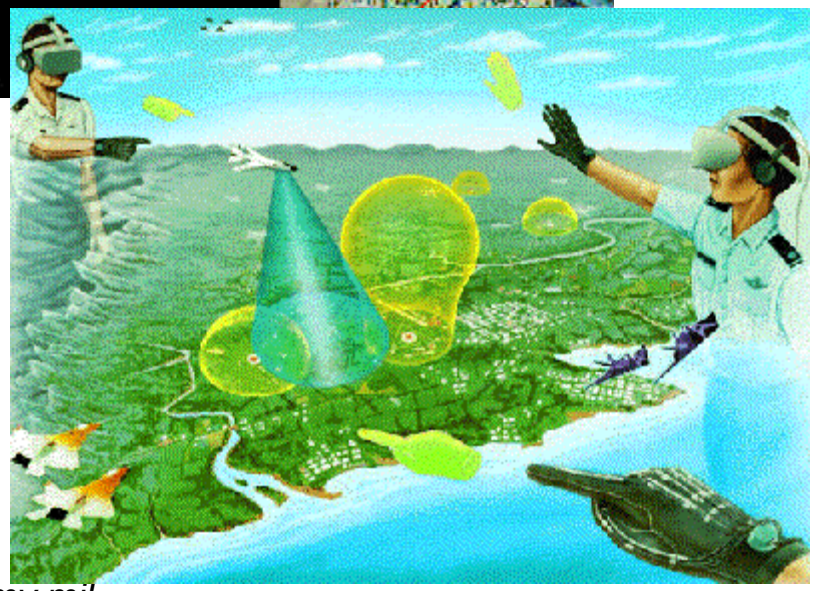


*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Evolving

- Real time simulations of the battlefield





smithh2@wes.army.mil

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

**Information is no longer a staff function but an operational one. It is deadly as well as useful**

**Lt. Gen. J. W. Kelly-Air Force 2025 Final Report**



*smithh2@wes.army.mil*

THE CADD/GIS TECHNOLOGY CENTER
for Facilities, Infrastructure, and Environment

# Introduction to Geographic Information Systems (GIS)

# Questions

CADD/GIS Technology Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199



*smithh2@wes.army.mil*